Welding Metallurgy
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Lecture – 39
Measurement of Residual Stresses in Weldments

Welcome to the lecture on measurement of residual stresses in weldments. So you know we talked about the you know emanation of residual stresses in the weldments and that is because of the you know thermal cycling or the temperature through which the zones undergo you know the cycle. So you know we must know we must be acquainted with the methods which should tell us to find you know the residual stresses in the components.

So the components may be any component maybe cast component or weld component. So there are ways to find you know the residual stresses which are there inside the weldment and you may have the experimental methods and you may have the you know analytical method to find the you know residual stresses in the components among the experimental you may have the destructive methods and you may have also have the non-destructive methods of finding the residual stresses in the weldments.

So we will talk about mostly about the you know destructive type of methods which are used for finding or for measuring the residual stresses in the weldments.

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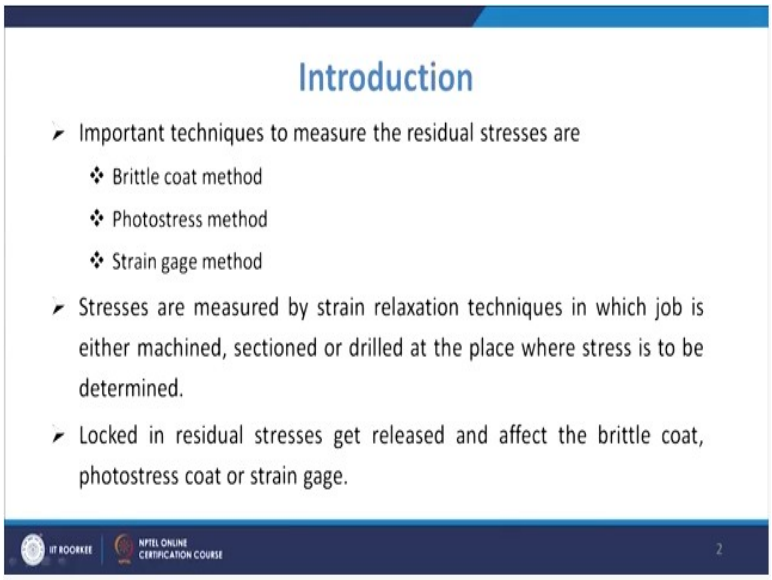

So the important techniques the common techniques which are available to measure the residual stresses are brittle coat method then you have photostress method, strain gage method and also other methods. So you know what we normally do is that you have the methods to you know to measure the stresses and using that you know the strain relaxation techniques. So either the job will be machined or you know we are drilled at a place where that stress has to be you know calculated.

So accordingly we calculate you know these stress values. So if you come to the first method that is your brittle coat method so the you know concept is that what we normally do is that you provide a coating on the surface and then you do some drilling. So what happens that residual stresses as we have you know understood that is locked in stresses and you know they have to be released.

So when you are you know doing a drilling or machining operation then these are basically released from there. So you will have the re change in the you know dimensions also because there so they are having under the stress. So there are different methods and you know by that we try to measure these you know stresses or to know that you know what is the residual stress. Otherwise certainly for measuring stress you have the you know rules.

So you will have the stress-strain rules so based on that also you can find. But otherwise metallurgically you know or for the experimental you know investigation side will discuss few of the methods just to have a feeling that how these are measured. So the first method is what we discussed is the brittle coat method.

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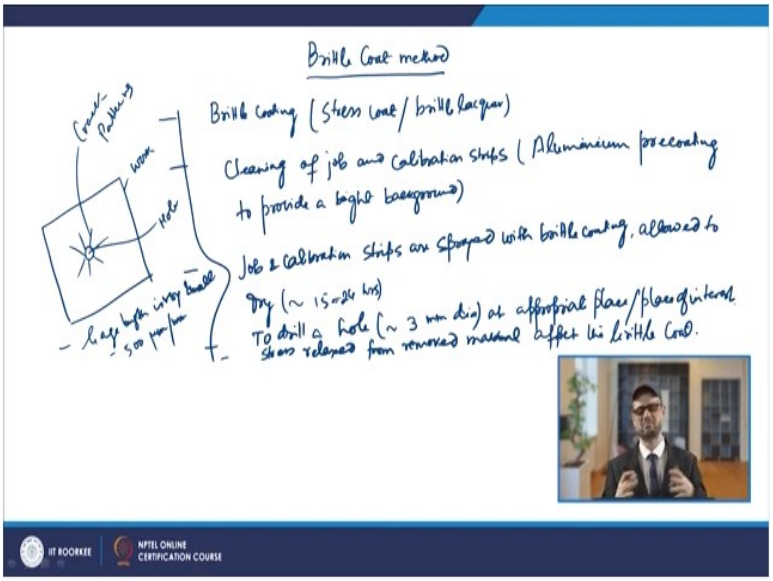

So as the name indicates in this method you provide a coating so what you do is you provide a you give a so brittle coating. So you are making a layer of brittle coating so that is also known known as the stress coat or the brittle lacquer. So also known as the stress coat or brittle lacquer. So basically it is a ?????? you know and then you know you have also the dibutyl phthalate so that is with the carbon disulphide you know as the solvent.

So that is the material for that metal coating. Now these coatings are commercially available you know in the market so you can have those brittle coatings. Now you know what coating has to be how much you know when the coating has to be done. So for that you have the specified you know conditions are there like temperature and humidity conditions. So that you know that on that basis you will have to select the appropriate coating.

Now once you have the coating then what you do is that you know you have to clean. So cleaning of job and calibration strips so you know so they are so what you do is you also give a precoating with aluminium. So that you are having a you know bright background so first of all

you give these you know the with aluminium you are giving a precoat and then you provide this brittle coating so that you know when this pattern will come out then you can have the you know more you know bright visibility.

So what you do is you give aluminium precoating to provide a bright background. So the precoating basically will be drying in some time maybe close to 15 to 20 minutes. Then you know provide this you know coating. Now these you know job and calibration strips so that will be so job and calibration strips are spread with the brittle coating. So then once you give this brittle coating on the job and also in the calibration strips.

Then they are allowed to dry and that may take very, very long time. So you know the drying time is normally about 15 to 24 hours. So since it is a brittle you know coating so that becomes quite hard you know on drying. So then now the place where you have to find you know the residual stresses. Now they are basically you have to locate those places and then at that place you have to drill you know a hole.

So what you do is to drill a hole normally you take a 3 mm dia hole you know and at appropriate place or you have place of interest where you know wherever you have to find the residual stress at that place you are you know drilling a hole of about you know 3 mm. So what happens that now once you remove the material so because of the removal of the materials you know the stresses are relaxed and that will be affecting the brittle coat on the material.

So basically you know that because of that you will have you know because they are completely adhered to the surface of you know the you know work. So as there will be any you know so since there will be stress adjustment so there will be some movement and because of that you know there will be cracks will be there to accommodate those you know movements so you will have the cracks on the surface you know in that battle coat.

So you know so the stress relaxed from removed material so that will affect the brittle coat. So you know so what will happen you will have the presence of a crack pattern which will be observed and the job will be basically stressed to the biaxial type of you know tensile stresses. So

what will happen if you have suppose a job if you have a job like this if you have this is the you know suppose they are casting.

Now in this case if you suppose draw this drilled hole so what will happen you will have you know the cracks which will be you know seen like this you know on the you know all around this so that on that brittle coat. So this will be the crack patterns. So this is your you know this is the hole which you are drilling and this is your work. So you know so what happens that these calibration strips are there.

So they are subjected to the biaxial stresses because you have the you know stresses which are released and you are talking about on the surface you have biaxial stresses are there. So you know so you will have the you know you have the load point of initial cracking and then your strain in that you know strain scale that is also measured. So what is the change in that dimension so you have the calibration strip so you can understand the change in the length.

So you can measure that way the strain and then you will have the calculation of the residual stresses. So basically you know again you have to use those you know stress-strain rules to find because you know these you know strain and strains in and the different directions. So based on that you can measure you know the stresses from the empirical you know formulas. So this is how you know you use these brittle coat method to find you know the residual stress in a component.

So it will be giving you so brittle code method normally will be giving you a quantitative you know estimation of the residual stress you know close to you know the accuracy of about 10%. So that is normally the you know degree of you know correctness of the data you know which is obtained with the brittle coat method. Now you know in this case you can so and it is also to use as for detecting that you know static and dynamic strains in tension or the compression.

So what the traits of these method is that in this case you know the gauge length is very, very small. So your gauge length is you know very small and also you have the you know you can have your smallest measurable strain which you can measure is about 500 μm by mm. So that is

normally that type of strains can be measured. So you will have these you know rate of strain will be something you know close to point 0.05 to 0.1 you know 0.15%.

So I mean of that order this strain value will be you know can be measured and that way you can calculate these stress values. Next method which is which we discussed was the photo stress method.

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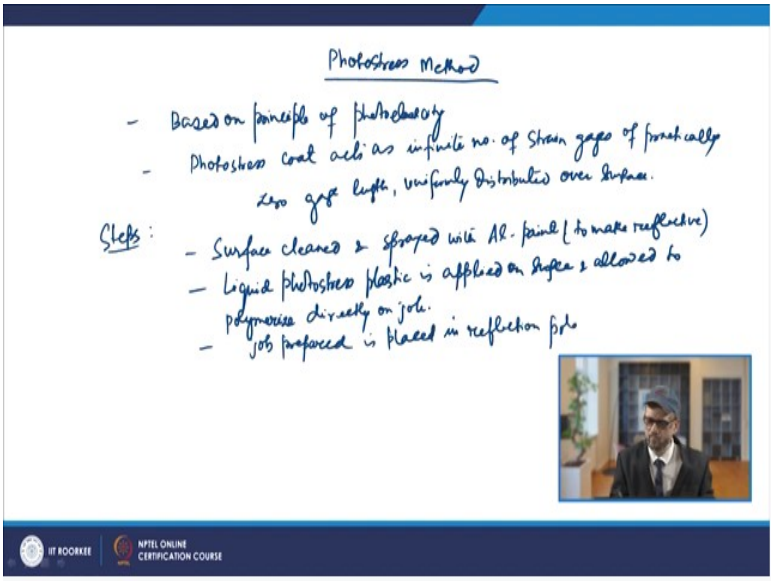

So in the case of photo stress method so this method is based on the principle of photo elasticity. So this is based on principle of photo elasticity. So you know in that case using the relaxation techniques you can you know find the stresses in actual you know objects. So based on that principle you have here the use of the photo stress coat. So in this case again you have the photo stress coats are available.

So photo stress code that will be acting as the infinite number of strain gages. So acts as infinite number of strain gages. So normally that will be of practically of zero gauge length of practically zero gauge length. So you know and you are basically uniformly distributing over the surface where the stress is to be calculated so uniformly distributed over surface. So in this case also again you have the similar type of you know procedure which is followed.

Now in this case what we do is so your step is that again you apply you know the surface of the first of all your surface will be you know cleaned and sprayed with aluminium paint. So surface cleaned and sprayed with aluminium paint. So again we are doing this to have very reflective surface and you have a bright surface. So for that you are you know cleaning that basically for the reflective you know to make the surface very reflective.

Now what we do here is in this case we use this liquid you know photo stress plastic so that is applied on that you know prepared surface. So liquid photo stress plastic is applied on the surface so you know once you apply this liquid photo stress plastic and then you allow it to polymerize so and allowed to polymerize and you know directly on the job.

So one is that you can have the use of liquid photo stress plastic or you may have you know the use of transparent you know the photo stress materials also which can be you know bonded on the surface of the job. So that way also you can have you know the use. Now this once you have made this then now this is placed in the so this job you know that is prepared job prepared is placed.

So that is in reflection polariscope. So what we do is normally we again here also we drill a hole and then you know so again dealing the hole will be to just you know have the understanding about the stresses which are there you know residual stresses which are there inside the material. So that way the strains will be relaxed you know and that will be affecting this you know photo stress coat.

Now what is happening that in this case your so your if you look at the you know the apparatus what is there is you have a you know light source.

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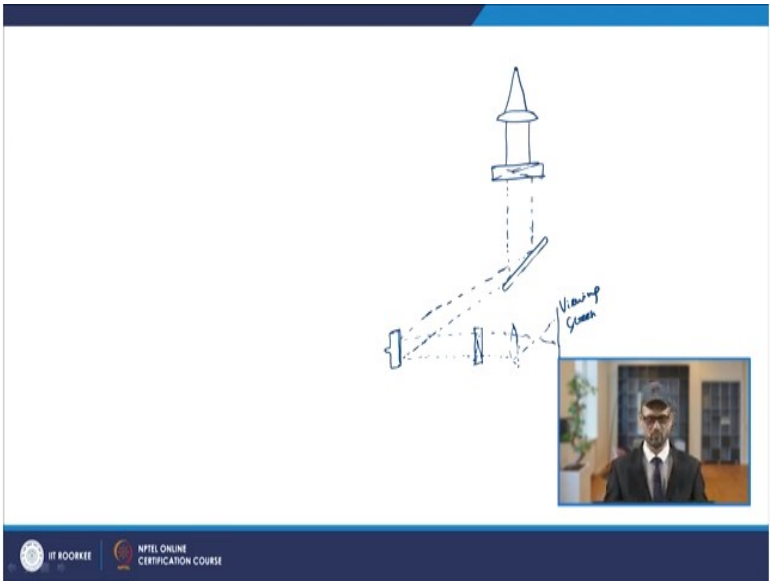

So you have a light source here and then you have a lens system. So from the light source you will be having the light you know light and then you have the lights coming through it. Now it will be passed through a polarizer. So you will have a polarizer which is there in it and then now you know you will have so from here again the light comes down and here you have you know so you have the mirror.

So mirror is kept you know at some angle so once it comes here so it will be reflecting and it will be you know reflecting in this fashion. And similarly this striking here and that also will be you know going parallelly in this fashion. Now that will be so you will have the you know job here now if you come further down. So you will have the you know the stress coat which is provided on a specimen and you have a welded specimen.

Now you know from here it you know it goes so it becomes birefringent so this way it will go and then you will have the you know again you have the you have to this you know passing through the lens and that you will know it will pass through lens like this and you can see it on the you know viewing screen. So you will have this the viewing screen is there. So again you have in between you have a polarizer here.

So the job is basically this this is the light source from here this light will come and the purpose is that you know it will be turning so because of the change in this photo stress coating because

of the stress released you know the so that way it becomes birefringence so that is doubly refracting and the plane polarized light basically it will be passing through that affected you know photo stress material.

So basically it will be changed into two you know two component that is mutually perpendicular rays and then you know they are parallel and perpendicular to the direction of the stress so you have accordingly you know you will see these you know on this viewing screen. So this on this you will be having the light and dark fringes. So that basically will be giving you the idea about the distribution of the principle stresses which is there on this screen.

So when you observe it through the you know reflection polariscope what you see? you see two sets of basically bands so that is seen in that strain you know photo stress coating. So accordingly you will have you know so those are basically you have the isoclinics and you have isochromatics. So isoclinics refers to you know the black bands so that gives you the direction of the principle strains.

And you have the isochromatics so that is the coloured fringes which you obtain and it will be giving you the maximum shear strain you know that it is magnitude of the maximum shear strain. So you will have so you have one only one reading of the fringe with the light going under the normal incidence through that you know photo stress coat.

So that way you know you have the pattern of these coloured fringes which is you know the function of the strain distribution which will be you know so here that pattern will be measuring that strain distribution and you know and peak of the strain or so can we even you know determined. So you can have the location and you can have the you know sign and magnitude of that strain maximum that can be measured by looking at the fringes which you get on that you know viewing screen.

So this is the method of you know the photo stress method which is used for calculating these residual stress values. Now the next method which is used is the you know the strain gage method.

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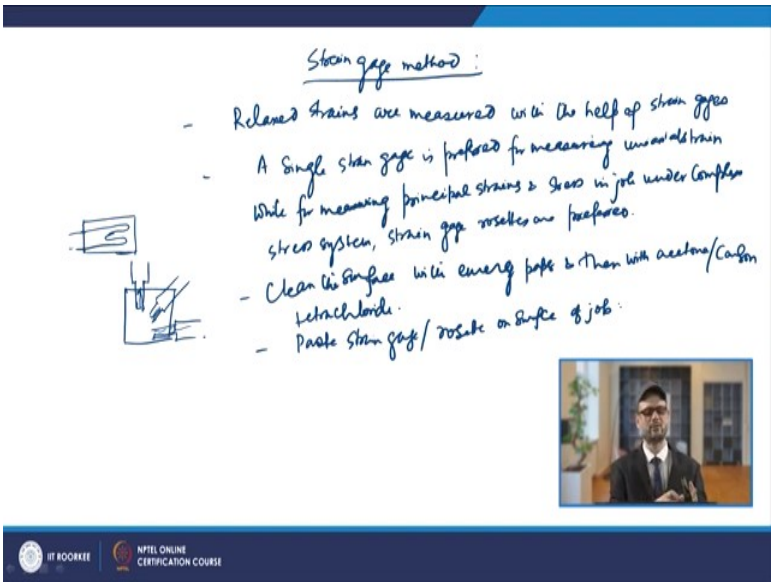

Now in the case of you know strain gage method so you are again in the case of you know in the other two methods you are basically drilling the hole and you are you know so measuring those strains. So here also you have these strain gauges you use these strain gauges and so strain relaxed will be measured and then you know so that is measured again for by drilling a hole into the material.

And then accordingly you know so you will have a strain rosettes here and then you know accordingly you will have so you will have the measurement automatically of the strains and based on that you can measure these you know stress values. So you know so you will have here you have the relaxed strains are measured with the help of strain gages. So you have you know you may have single strain or gage or you may have many.

So you know so a single strain gage so single strain gage will be measured for the uniaxial strain so that is preferred for measuring uniaxial strains but if you have to measure you know the complex stress system then you have a strain gage rosette is used so while for measuring principle strains and stresses in job under complex stress state you know what you do is you use the strain gauge rosette are preferred.

So you will have you know when you have a single one so you will use you know for so you will have one you know one strain rosette so that is basically you know there for you know single uniaxial strain whereas if you have the you know for the complex stress state if you have to calculate in that case you will have the you know so in any axis in this domain you will have this different you know the stress.

So this is one this is you know the another and similarly you will have the you know so this will be this way you will have the you know so you will have the you know system of the strain gages that is strain rosettes. So they are used basically in these cases so you will have that is known as the you know strain rosette. So in this case also what you do is you have to first clean that surface with the emery paper.

So you have to first of all you clean the surface with emery paper and then with acetone or carbon tetrachloride. Now after doing that what you do is you have to paste that strain gage or the rosette on the surface. So paste you know strain gage or rosette on the surface. So you know they can be fixed you know on any specimen which is welded. So that can be you know measured.

So once you have the drilling of the hole in that case these strain gage rosettes you can measure these you know strains. So basically you have these strain gage rosettes at you know the different angle you know this is 0 degree, 45 degree and 90 degree you have the you know strain gage rosettes are fixed. So that will be calculating the strains in these three principle directions and then you know once you know the strains you know which are the measured then based on that you can calculate the stress values in the you know specimen.

So that way you know use of these strain gages which are based on the electrical signals. So you can measure these stresses and understand what is the amount of residual stress which is stored inside the material. So even after that also you apart from these destructive methods you have many kind of non-destructive methods also for you know calculating the you know the residual stress values. So this is about you know the calculation methods of residual stresses in the welded specimen. Thank you very much.